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The Eastern Palaearctic *Cosmopterix feminella* Sinev, 1988, introduced in Italy: taxonomy, biology and a new synonymy (Lepidoptera, Cosmopterigidae)

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Abstract. *Cosmopterix feminella* Sinev, 1988, previously known from the East Palearctic, Primorskiy Territory in Russia and Japan has been collected at light in Europe. In northern Italy 58 females were collected in two localities in the province Asti, two in Alessandria, three in Udine, and in one locality in Pordenone. *Cosmopterix feminella* is most likely parthenogenetic as only females are known. The caterpillars are leafminers on grasses. The species is redescribed and illustrated. DNA barcodes are provided and compared with other European species. *Cosmopterix feminae* Kuroko, 2015 is synonymised with *C. feminella*. The species was probably accidentally introduced into Italy.

Introduction

The genus *Cosmopterix* Hübner, 1825 (Gelechioidea: Cosmopterigidae) comprises small, sometimes very small, moths with a striking and often beautiful forewing pattern. The majority of the species can easily be recognized by the broad yellow to orange fascia on the forewing. This fascia is often bounded by tubercular golden or silver metallic fasciae or spots. The wings are very narrow and acutely pointed. The larvae are leafminers, usually oligophagous or monophagous and have been found in the following plant families: predominantly on Cyperaceae, Fabaceae and Poaceae, fewer species on Asteraceae, Cannabaceae, Convolvulaceae, Dipterocarpaceae, Hydrangeaceae, Lamiaceae, Theaceae and Urticaceae (Robinson et al. 2010; Kuroko 2015; Koster 2016). The genus occurs on all continents except Antarctica. The majority of the species have been found in tropical areas, while in temperate climates the number of species declines rapidly towards the poles. Europe (including Macaronesia) being well explored, has only 13 species recorded (Koster and Sinev 2003; Huemer and Koster 2006). Sinev (1997) mentioned 40 species in his review of the genus from the whole Palaearctic region, of which 12 species were also known from Europe.

Recently the number of species of the Palaearctic region further increased through the revision of the fauna of Japan by Kuroko (2015), who listed 49 species for this country, of which 25 were described as new. On the basis of these data, Sinev (2002) and Koster (2016), the total number of species worldwide is currently 344.

In Italy in June 2015 eight specimens of an unknown *Cosmopterix*-species were collected in a light trap in Cascine Bet, near Mombarone (Asti, Valmanera biotope) in the region Piemonte by O. Maioglio. An additional specimen of this unknown species was collected in a light trap by C. Cabella in September 2016 in Pertuso Le Strette, Cantalupo, also in the region Piemonte, roughly about 90 km east of the first locality. This material was brought to the attention of Giorgio Baldizzone who sent the material to the first author. Almost simultaneously, between August 2015 and September 2016, Helmut Deutsch collected six females in the region Friuli Venezia Giulia in three localities in the province Udine at light. It was tentatively identified as *C. crassicervicella* Chrétien, 1896 and sequenced in the framework of the barcoding campaign "Lepidoptera of the Alps". More material from the same and more localities became available in 2017 and 2018.

The collected specimens resembled *Cosmopterix attenuatella* (Walker, 1864) and *C. crassicervicella*, but lacked the orange brown or orange yellow markings on the dorsal side of the abdomen. After the examination of the female genitalia the species could be determined with certainty as *C. feminella* Sinev, 1988. DNA barcodes showed that the species from Piemonte and Friuli Venezia Giulia were conspecific.

Here we report the species new for Italy and Europe, and redescribe it in the format of the Microlepidoptera of Europe book series (Koster and Sinev 2003) and provide DNA barcodes.

Material and methods

Material. The material from the region Piemonte has been collected with Actinic light and a light trap. Similarly specimens from Friuli Venezia Giulia were all collected at light. Material is listed in Table 1, and more detailed in Suppl. material 1.

Morphology. Genitalia were dissected following the methodology presented by Brown (1997) and Robinson (1976). Chlorazol black was used to stain the unsclerotized parts of the female genitalia.

The morphological terminology follows Koster and Sinev (2003) and Koster (2016). In *Cosmopterix* the sterigma, formed from lamella antevaginalis and lamella postvaginalis, in the female genitalia is important for identification. It is often poorly sclerotized and can easily be distorted by too much pressure on the coverslip of the genitalia slide. Therefore the sterigma has been depicted here in both ventral and lateral position.

Illustrations. The photograph of the adult was taken with a Zeiss AxioCam digital camera attached to a motorized Zeiss SteREO Discovery.V12, using Carl Zeiss AxioVision software. The female genitalia were depicted in line drawings in ventral position, and the drawing of the enlarged sterigma are given separately; these drawings have been reduced to 70% of the original drawing size. Drawings of the genitalia were made with a compound microscope using the camera lucida method. For this purpose a strong light source (slide projector) was used for the illumination on the mirror of the microscope. A prism was placed on top of the microscope eyepiece to bend the projection 90° and project the subject on drawing paper. All outlines were drawn by pencil and later set in Indian ink. Scale bars alongside the drawing show the size of the genitalia in 0.1 mm.

The map (Fig. 5) was prepared with ArcGIS software.

DNA extraction and sequencing. DNA barcodes of two specimens of *C. feminella* (RMNH.INS.15509 and RMNH.INS.15510) were derived from extracts taken from abdomens following the procedures outlined by van Nieukerken et al. (2012a) and Doorenweerd et al. (2015), the abdomen and genitalia were taken from the lysis and prepared by JCK in the normal way. Legs of four other specimens were sent for analysis to the CCDB (Canadian Centre for DNA Barcoding, University of Guelph, Canada) where DNA extraction, PCR amplification, and sequencing were performed following standard high-throughput protocols (deWaard et al. 2008). The resulting COI sequences are combined with those from a representative set of other European *Cosmopterix* species from our own projects, or being publicly available, in the public BOLD dataset "Cosmopterix feminella in Europe [DS-COSMFEM]" [doi: 10.5883/DS-COSMFEM] and GenBank (Suppl. material 1). Unfortunately we have no barcode of the closely related *C. attenuatella* available from European samples, in BOLD there are only two incomplete barcodes from Galapagos and North America respectively, not yet in the public domain. The Neighbour Joining tree was prepared with the tree building tools on BOLD (Ratnasingham and Hebert 2007) and edited with Adobe Illustrator.

Results

Cosmopterix feminella Sinev, 1988

Figs 1–5

Cosmopterix feminella Sinev, 1988: 709. Holotype ♀, Russia: Primorskiy Kray, Khasanskiy district, 3 km southeast Andreyevka, 5.viii.1985, Sinev (Coll. Zoological Institute, Russian Academy of Sciences, St. Petersburg) [examined].

Cosmopterix feminae Kuroko, 2015: 48. Holotype ♀, Japan: Mt. Hikosan, Fukuoka Pref., 26.vii.1955, reared from *Digitaria violascens*, Kuroko. (Coll. Entomological Laboratory, Osaka Prefecture University). **Syn. n.** [not examined].

Material examined. Italy: 58♀. See Table 1 and Suppl. material 1.

Diagnosis. In Europe *C. feminella* resembles *C. crassicervicella* and *C. attenuatella*. The latter species occurs in Europe only in the Macaronesian Archipelago. It differs from both by the narrower forewings, which are ten times as long as wide compared to eight times in *C. feminella* and *C. crassicervicella*. In the forewing *C. feminella* can be distinguished from both other species by the absence of a white costal line in the basal area and by the absence of the apical protrusion of the orange-yellow fascia, and in the abdomen by the uniform ochreous-brown dorsal coloration. In *C. attenuatella* the abdomen is dorsally more or less spotted orange-brown and in *C. crassicervicella* the abdominal segments two to six are dorsally orange-yellow. The female genitalia of *C. feminella* can be recognised by the large central hump on the posterior edge of sternite VII, by the distally hood-shaped sterigma and by the small but prominent crescent-shaped signa.

Redescription. Female (Fig. 1). Forewing length 3.9–4.1 mm. Head: frons shining grey with greenish and reddish reflections; vertex and neck tufts shining dark brown with reddish gloss, medially and laterally narrowly lined white; collar shining dark brown with reddish gloss; labial palpus, first segment very short, grey, second segment four-fifths length of third, both segments dark brown, dorsally and ventrally lined white. Antenna: scape dorsally shining brown with reddish gloss and white anterior line, ventrally shining white; flagellum shining dark brown with short white line from base, changing in annulated white line to one-half, followed towards apex by four to five dark brown, one white, one dark brown, one white, four dark brown and three to four white segments at apex,

Table 1. Localities and material of *Cosmopterix feminella* in Italy. More details in Suppl. material 1.

# ♀	Region	Province	Locality	Collector	Date	DNA Barcodes
2	Friuli Venezia Giulia	Pordenone	Bachbett Torrente Cimoliana, Umg. Cimolais	Toni Mayr	24.vi.2017	
1	Friuli Venezia Giulia	Udine	Colloredo, Prati di Lavia	H. Deutsch	3.viii.2016	
3	Friuli Venezia Giulia	Udine	Confl. Torre-Natisone, Medeuzza	H. Deutsch	13.viii.2015	TLMF Lep 22239, 22240, 24198
2	Friuli Venezia Giulia	Udine	Interneppo, Mt. Festa	H. Deutsch	2.ix.2016	TLMF Lep 22241
2	Friuli Venezia Giulia	Udine	Risorgive di Flambro-Virco	H. Deutsch	4.viii.2016	
1	Piemonte	Alessandria	Cantalupo, Pertuso, Le Strette	C. Cabella	5.ix.2016	RMNH.INS.15510
1	Piemonte	Alessandria	Montechiaro d'Acqui, località Vaccamorta	G. Baldizzone	13.ix.2018	
1	Piemonte	Asti	fraz. Mombarone, Cascine Bet	O. Maioglio	11.vi.2015	
7	Piemonte	Asti	fraz. Mombarone, Cascine Bet	O. Maioglio	12.vi.2016	RMNH.INS.15509
15	Piemonte	Asti	fraz. Mombarone, Cascine Bet	G. Baldizzone	12.ix.2016	
1	Piemonte	Asti	fraz. Mombarone, Cascine Bet	G. Baldizzone	28.vii.2017	
8	Piemonte	Asti	fraz. Mombarone, Cascine Bet	G. Baldizzone	31.viii.2017	
4	Piemonte	Asti	fraz. Mombarone, Cascine Bet	O. Maioglio	14.ix.2018	
9	Piemonte	Asti	Valmanera, sotto Cascina Giardina	O. Maioglio	9.viii.2017	

sometimes apical segment grey to dark brown. Thorax and tegulae shining dark brown with reddish gloss, thorax with white medial line, often widening posteriorly, tegulae narrowly lined white inwardly. Legs: shining dark brown with reddish gloss; foreleg with white line on tibia and tarsal segments one to three and five; tibia of midleg with white oblique basal and medial lines and white apical ring, tarsal segments one and two with greyish white apical rings, tarsal segment five white; tibia of hindleg as midleg, tarsal segments one to four with narrow white apical rings, segment five dorsally white; spurs shining white, ventrally more grey. Forewing shining dark brown with reddish gloss; four white lines in basal area, subcostal from base to one-fourth and bending inwardly in distal half, short medial from one-fifth to just beyond subcostal, subdorsal underneath medial, about as long as medial or reaching slightly beyond it, very narrow dorsal from base to one-fifth, sometimes hardly visible; bright orange-yellow transverse fascia beyond mid length, narrowing in dorsal half; bordered at inner edge by broad tubercular golden metallic fascia, narrowing towards costa and with small subcostal patch of black scales on outside; bordered on outer edge by two tubercular golden metallic spots at costa and dorsum, dorsal about twice as large and nearer to base, costal and dorsal spots inwardly edged by few blackish scales; rather broad greyish white costal streak, inwardly edged dark grey; longitudinal silvery white spot in middle of apical area and shining white line in apical cilia; cilia dark brown around apex, paler towards dorsum. Hindwing shining brownish grey with reddish and greenish gloss; cilia dark greyish brown. Underside: forewing shining greyish brown, white costal and apical line distinctly visible; hindwing shining grey. Abdomen dorsally shining ochreous-brown with reddish golden gloss, laterally shining grey, ventrally shining grey, segments broadly banded white posteriorly; anal tuft dorsally ochreous-brown, ventrally blackish brown.

Male genitalia. Male unknown.

Female genitalia (Fig. 2a–c). Posterior edge of sternite VII deeply concave with very large convex hump in centre. Sterigma elongated, distally hood-shaped, ostium bursae rounded, basally V-shaped with rounded labiate extension. Ductus bursae narrow, slightly shorter to about as long as corpus bursae. Ductus seminalis from upper part of corpus bursae. Corpus bursae elongate, two small, crescent-shaped signa.

Figure 1. *Cosmopterix feminella*, female habitus, Asti, Cascine Bet, 12.vi.2016, RMNH.INS.15509. Scale bar: 2 mm. Photo J.C. Koster.

Biology. The biology has been described by Kuroko (2015) (as *C. feminae*), from which we cite the following. Host plants: *Digitaria ciliaris* (Retz.) Koeler and *D. violascens* Link (Poaceae). Larva (last instar): head blackish brown, body cylindrical, pale yellow, prothoracic shield and anal plate black, prothoracic legs blackish brown. The larva mines the leaves and makes an irregular blotch mine from near the base towards the apex of the leaf. The frass is ejected from a hole at the beginning of the mine. The larva changes leaves to make more than one mine. Pupation takes place outside the mine in a spindle-shaped whitish brown cocoon in a folded space on a leaf. In Japan (Kyushu: Mt. Hikosan) up to four generations per year occur. The larva of the last generation hibernates full grown and pupates in the middle of May the following year. The adults are on the wing in late May, in late July, from mid-August to mid-September and in late October. The European specimens of *C. feminella* were collected in the months June, August, September and October.

Distribution. Russia: Primorskiy Territory, Japan: Honshu and Kyushu, Italy: Piemonte and Friuli Venezia Giulia regions (Fig. 5).

DNA barcodes. We obtained completely identical DNA barcodes from six specimens of *C. feminella* from Italy, all belonging to the new Barcode Index Number BOLD:ADG7284, and with a distance of 5.8% to the nearest neighbour, an unidentified *Cosmopterix* species from Madagascar with BIN BOLD: ACT2622 (specimen BIOUG18998-F03). This specimen was collected with a Malaise trap and therefore its external morphology is poorly preserved (Lopez-Vaamonde et al. 2018). Unfortunately no barcodes are yet known from the Asian populations. The distance to barcodes of European species is larger, the smallest being 6.1% to *C. scribaiella* (Zeller, 1850) (Fig. 6).

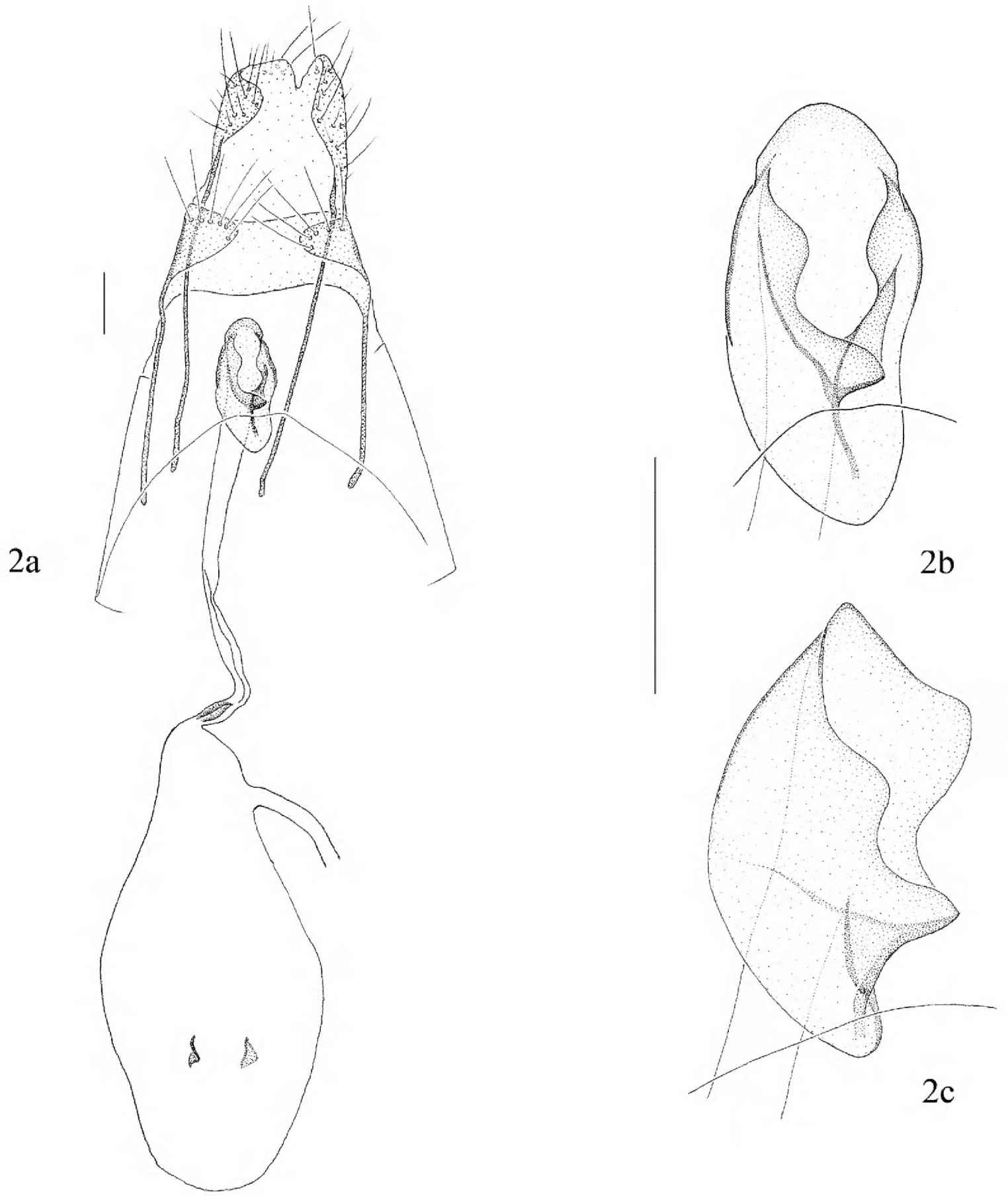

Figure 2. *Cosmopterix feminella*, female genitalia. **2a**. ventral aspect, genitalia slide JCK8673; **2b**. sterigma enlarged, in ventral view, genitalia slide JCK 8673; **2c**. sterigma enlarged in lateral view, genitalia slide JCK 8674. Scale bars: 0.1 mm. Drawings J.C. Koster.

Remarks. *Cosmopterix feminella* has been described on the basis of four females, caught between 25 July and 15 August in Primorskiy Kray, in the south-east of the Russian Far East.

In his study on the genus *Cosmopterix* of Japan, Kuroko (2015) described a new species, *C. feminae*, based on reared females only, and compared it with *C. feminella* from Russia, of which

Figures 3, 4. Collecting sites of *Cosmopterix feminella* in Italy. **3.** Asti, Cascine Bet. Photo G. Baldizzone; **4**. Udine, Medeuzza, Confl. Torrente Torre-Natisone. Photo H. Deutsch.

Figure 5. Map of collecting localities of *Cosmopterix feminella* in Italy.

also only females were known. His conclusion was that the Japanese species shows sufficient differences to describe it as a new species, based on the following features: the apical segment of the antenna is black in *C. feminae*; but white in *C. feminella*; in the forewing the subcostal line starts from the base of the wing in *C. feminae*, which is not the case in *C. feminella*; in the female genitalia the sterigma (lamella antevaginalis) lacks the tongue-shaped extension at the top as seen in *C. feminella*; the ductus bursae is about half the length of the corpus bursae in *C. feminae* instead of nearly the same length in *C. feminella*.

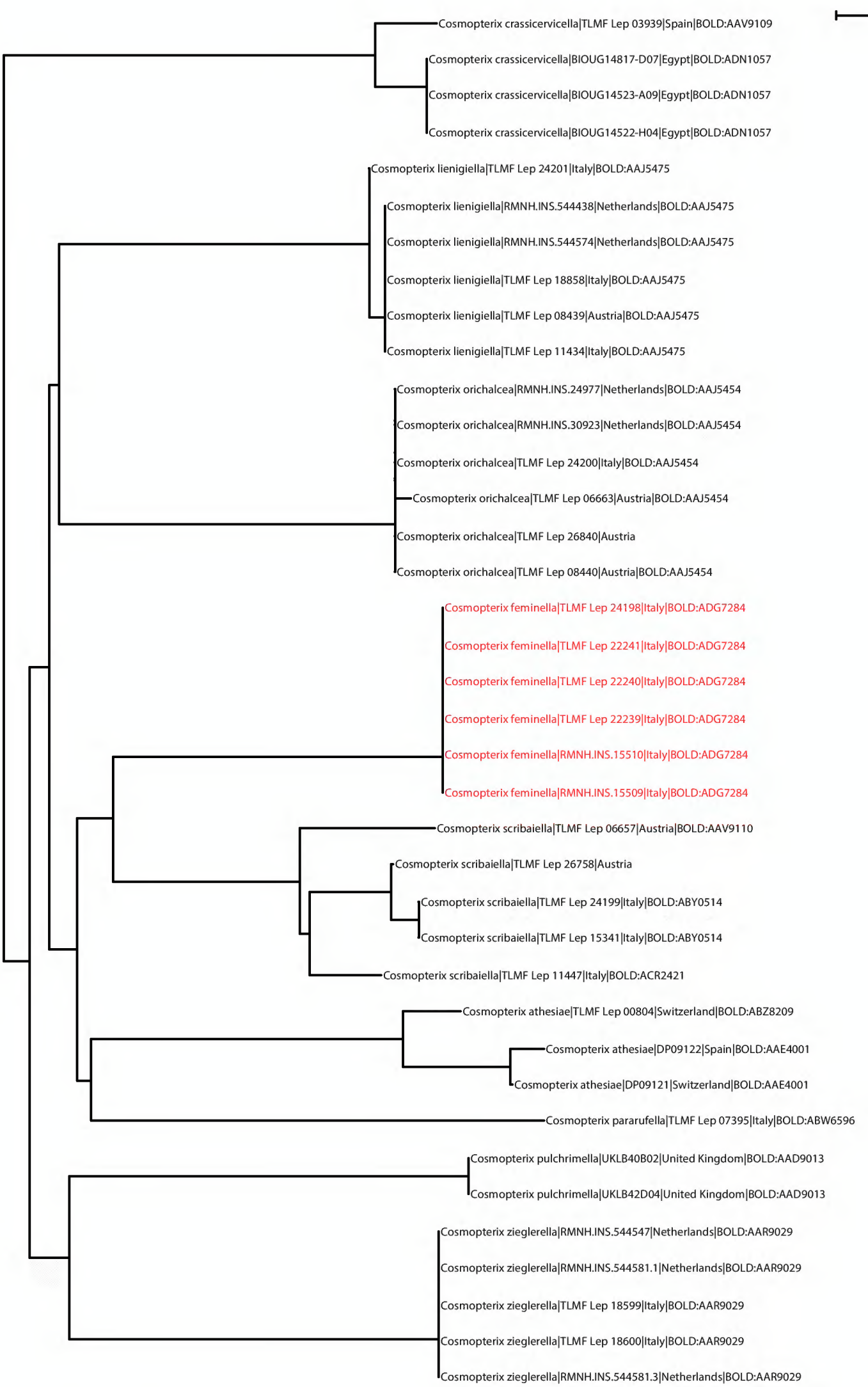

Figure 6. Neighbor Joining tree of DNA barcodes of European *Cosmopterix* species.

Cosmopterix feminae is here synonymized with *C. feminella* for the following reasons: In the European series from Italy the apical segment of the antenna is white in 12 specimens, but it is dark grey in two specimens and black in one specimen, thus this character is apparently not constant. According to the original description of *C. feminella* the subcostal line also starts from the base of the forewing. Sinev (1988) provided a drawing of the forewing in which the subcostal line does not reach the base of the wing. Actually it does start from the wing base, but the curve of the wing margin hides this when seen from above, as in the figure. Probably this has convinced Kuroko that this line starts beyond the base of the wing. As Sinev (1988) mentioned, the tongue-shaped extension at the top of the sterigma (lamella antevaginalis), belongs to the hood-shape form of the sterigma. When the sterigma is embedded on the genitalia slide in ventral position, the so-called tongue-shaped extension can be caused by pressure on the cover slip. Kuroko (2018) described the length of the ductus bursae as about half the length of the corpus bursae, however, in his drawing (Plate 21, fig. H) the length of the ductus bursae is only slightly shorter than the length of the corpus bursae and equal in length to the length of the ductus bursae compared to the corpus bursae in the drawing by Sinev (1988: fig. 2, below in centre). The above differences are thus considered insufficient to regard *C. feminae* as a separate species.

Discussion

The type series of both *C. feminella* from Russia and *C. feminae* from Japan, including reared material, consist of females only. On this basis Kuroko (2015) suggested the possibility of parthenogenesis. Also all specimens found in Italy are females. All this taken together suggests that it is very likely that we are dealing here with a parthenogenetic species, although confirmation from e.g. rearing experiments is required for more certainty.

The finding of so many specimens of a species otherwise only known from the eastern Palearctic, thousands of kilometres away, is probably best explained by accidental introduction. How this happened is difficult to trace, but it is likely aided by human transport, either imported with plant material from Asia, introduced unintentionally as a contaminant with foreign grass seed, or even as adults inside some means of transport. One piece of grass with a pupa might have been sufficient, as for introduction of a parthenogenetic species just one specimen could be enough. Globalization has led to an increasing number of introduced alien insects from many parts of the world (Roques et al. 2016). From all alien Lepidoptera known from Europe around 2009, most species originated from Asia (Lopez-Vaamonde et al. 2010), but for leafminers this number is relatively low, with best known example *Phyllonorycter issikii* (Kumata, 1963) on *Tilia* species, whereas most alien species originate from North America (Kirichenko et al. 2018). In several cases, Italy was the first country where these leafmining aliens were recorded, as in *Parectopa robiniella* Clemens, 1863, *Antispila oinophylla* van Nieukerken & Wagner, 2012 and *Coptodisca lucifluella* (Clemens, 1860) (Hellrigl 2006; Nieukerken et al. 2012b; Bernardo et al. 2015). Not all introduced species are able to establish populations, as was probably the case in the single record of the Eastern Asian fern feeder, found in Austria: *Cuprina fuscella* Sinev, 1988 (Stathmopodidae) (Wieser 2004). Possibly, *Cosmopterix feminella* is not the first alien *Cosmopterix* species in Europe, the widespread *C. pulchrimella* Chambers, 1875, feeding on *Parietaria* species (Urticaceae) is suspected to have been introduced into Europe from North America (Koster 2010). It was first found in Croatia in the 1930s (Koster 2010), and it is still spreading northward (Parsons and Sterling 2004; Ellis 2019).

For establishing populations, it is important that the species finds suitable hostplants. Both cited hostplants are known as introduced plants in Europe. The distribution of *Digitaria ciliaris* has been discussed in detail by Wilhalm (2010). The species has been described from China, but is nowadays widespread in Europe, especially in the south, but becomes scarcer towards the north. The species is not easy to separate from the native European *D. sanguinalis* (L.) Scop. *Digitaria ciliaris* can be found in northern Europe in harbour areas, dumps, waste places, gardens, roadsides, etc. In southern Europe it is also accompanying grass in lawns and plantations. *Digitaria violascens* is native in tropical Asia and probably also in tropical America from where the type was described (Verloove 2008). In Europe it has been found in France and Italy in different habitats. It is possibly introduced unintentionally as a contaminant with foreign grass seed. However, it is quite possible that *C. feminella* also feeds on other grass species, and the genus *Digitaria* has three native species in south-western Europe (Verloove 2008), giving ample opportunities for the moth to establish populations. A focussed search for leafmines is the next step, and it remains important to follow the further establishment and invasion of this species in Europe. As long as the species is attacking only the currently known food plants, which have also been introduced into Europe, it will probably not have any environmental or economic impact.

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References

Bernardo U, Nieukerken EJ van, Sasso R, Gebiola M, Gualtieri L, Viggiani G (2015) Characterization, distribution, biology and impact on Italian walnut orchards of the invasive North-American leafminer *Coptodisca lucifluella* (Lepidoptera: Heliozelidae). Bulletin of Entomological Research 105: 210–224. https://doi.org/10.1017/S0007485314000947

Brown PA (1997) A review of techniques used in the preparation, curation and conservation of microscope slides at the Natural History Museum, London. Biology Curator 10: 1–34. http://www.natsca.org/article/455

deWaard JR, Ivanova NV, Hajibabaei M, Hebert PDN (2008) Assembling DNA Barcodes, analytical protocols. In: Cristofre Martin C (Ed.) Environmental genomics. Humana Press, Totowa, NJ, Environmental Genomics 410: 275–294. https://doi.org/10.1007/978-1-59745-548-0_15

Doorenweerd C, Nieukerken EJ van, Menken SBJ (2015) A global phylogeny of leafmining *Ectoedemia* moths (Lepidoptera: Nepticulidae): exploring host plant family shifts and allopatry as drivers of speciation PloS ONE 10: e0119586. https://doi.org/10.1371/journal.pone.0119586

Ellis WN (2019) Plant Parasites of Europe: leafminers, galls and fungi. http://bladmineerders.nl/

Hellrigl K (2006) Rasche Ausbreitung eingeschleppter Neobiota (Neozoen und Neophyten). Forest Observer 2/3: 349–388.

Huemer P, Koster JC (2006) *Cosmopterix athesiae* sp. n., a widespread new species from Europe and Africa (Lepidoptera: Cosmopterigidae, Cosmopteriginae). Veröffentlichungen des Tiroler Landesmuseums Ferdinandeum 86: 75–82. https://www.zobodat.at/pdf/VeroeffFerd_86_0075-0082.pdf

Kirichenko N, Augustin S, Kenis M (2018) Invasive leafminers on woody plants: a global review of pathways, impact, and management. Journal of Pest Science. https://doi.org/10.1007/s10340-018-1009-6

Koster JC (2016) The genus *Cosmopterix* Hübner of continental Sub-Saharan Africa (Lepidoptera: Gelechioidea: Cosmopterigidae). Tijdschrift voor Entomologie 158: 87–318. https://doi.org/10.1163/22119434-15802002

Koster JC, Sinev SY (2003) Momphidae, Batrachedridae, Stathmopodidae, Agonoxenidae, Cosmopterigidae, Chrysopeleiidae. Apollo Books, Stenstrup, Microlepidoptera of Europe 5: 387 pp.

Koster JC (2010) The genera *Cosmopterix* Huebner and *Pebobs* Hodges in the New World with special attention to the Neotropical fauna (Lepidoptera: Cosmopterigidae). Zoologische Mededelingen 84: 251–575. http://www.repository.naturalis.nl/document/193818

Kuroko H (2015) The genus *Cosmopterix* (Lepidoptera, Cosmopterigidae). Touka Shobo, Fukuoka, The Insects of Japan 5: 1–162.

Lopez-Vaamonde C, Agassiz D, Augustin S, De Prins J, De Prins W, Gomboc S, Ivinskis P, Karsholt O, Koutroumpas A, Koutroumpa F, Laštůvka Z, Marabuto E, Olivella E, Przybylowicz L, Roques A, Ryrholm N, Sefrova H, Sima P, Sims I, Sinev S, Skulev B, Tomov R, Zilli A, Lees D (2010) Alien terrestrial arthropods of Europe, chapter 11. Lepidoptera. BioRisk 4: 603–668. https://doi.org/10.3897/biorisk.4.50

Lopez-Vaamonde C, Sire L, Rasmussen B, Rougerie R, Wieser C, Allaoui AA, Minet J, deWaard JR, Decaëns T, Lees DC (2018) DNA barcodes reveal deeply neglected diversity and numerous invasions of micromoths in Madagascar. Genome. https://doi.org/10.1139/gen-2018-0065

Nieukerken EJ van, Doorenweerd C, Stokvis FR, Groenenberg DSJ (2012a) DNA barcoding of the leaf-mining moth subgenus *Ectoedemia* s. str. (Lepidoptera: Nepticulidae) with COI and EF1- α: two are better than one in recognising cryptic species. Contributions to Zoology 81: 1–24. http://www.contributionstozoology.nl/vol81/nr01/a01.

Nieukerken EJ van, Wagner DL, Baldessari M, Mazzon L, Angeli G, Girolami V, Duso C, Doorenweerd C (2012b) *Antispila oinophylla* new species (Lepidoptera, Heliozelidae), a new North American grapevine leafminer invading Italian vineyards: taxonomy, DNA barcodes and life cycle. ZooKeys 170: 29–77. https://doi.org/10.3897/zookeys.170.2617

Parsons M, Sterling P (2004) *Cosmopterix pulchrimella* Stt. now resident in mainland Britain. Atropos 23: 23–25.

Ratnasingham S, Hebert PDN (2007) BOLD: The Barcode of Life Data System [www.barcodinglife.org]. Molecular Ecology Notes 7: 355–364. https://doi.org/10.1111/j.1471-8286.2007.01678.x

Robinson GS (1976) The preparation of slides of Lepidoptera genitalia with special reference to the Microlepidoptera. Entomologist's Gazette 27: 127–132. http://idtools.org/id/leps/tortai/Robinson_1976.pdf

Robinson GS, Ackery PR, Kitching IJ, Beccaloni GW, Hernández LM (2010) HOSTS – a database of the world's Lepidopteran hostplants. Natural History Museum. http://www.nhm.ac.uk/our-science/data/hostplants/

Roques A, Auger-Rozenberg M-A, Blackburn TM, Garnas J, Pyšek P, Rabitsch W, Richardson DM, Wingfield MJ, Liebhold AM, Duncan RP (2016) Temporal and interspecific variation in rates of spread for insect species invading Europe during the last 200 years. Biological Invasions 18: 907–920. https://doi.org/10.1007/s10530-016-1080-y

Sinev SY (1988) Novye dannye po faune Uzkokrylykh Molej roda *Cosmopterix* (Lepidoptera, Cosmopterigidae) palearktiki. New data on the palaearctic fauna of the narrow-winged moths of the genus *Cosmopterix* (Lepidoptera, Cosmopterigidae). Zoologicheskii Zhurnal 67: 705–712. [In Russian]

Sinev SY (1997) Obzor Uzkokrylykh Molej roda *Cosmopterix* Hb. (Lepidoptera, Cosmopterigidae) Palearktiki. A review of the narrow-winged moths of the genus *Cosmopterix* Hb. (Lepidoptera, Cosmopterigidae) of Palaearctic Region. Entomologicheskoe Obozrenie 76: 813–829. [In Russian]

Sinev SY (2002) World catalogue of cosmopterigid moths (Lepidoptera: Cosmopterigidae). Katalog roskoshnykh uzkokrylykh molej (Lepidoptera: Cosmopterigidae) mirovoj fauny. Trudy Zoologicheskogo Instituta 293: 1–183.

Verloove F (2008) Studies within the genus *Digitaria* Haller (Poaceae, Panicoideae) in southwestern Europe. Candollea 63: 227–233. http://www.ville-ge.ch/cjb/publications/cando632/C632_227-233.pdf

Wieser C (2004) Die Schmetterlingsfauna der Auen im Oberen Drautal und weitere Erstnachweise für Kärnten und Österreich (Insecta/Lepidoptera). Carinthia II 194/114: 369–387. https://www.zobodat.at/pdf/CAR_194_114_0369–0387.pdf

Wilhalm T (2010) *Digitaria ciliaris* in Europe. Willdenowia 39: 247–259. https://doi.org/10.3372/wi.39.39203

Supplementary material 1

Specimen data *Cosmopterix feminella*

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Data type: Excel file

Explanation note: Specimen data, collection details, coordinates.

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